

# CHAPTER I

## INTRODUCTION

### 1.1 Importance of Mango Crop

Mango is a major fruit crop of India grown on 1.2 million ha with 9.2 million tones of annual production. India accounts for 56 per cent of world production (Chadha, 1989). The state of Andhra Pradesh is the largest mango producer with an annual production of 2.7 million tons (Chadha and Bhargava, 1996).

Mango is a highly remunerative crop compared to other field crops, with a benefit-cost ratio of 2.8 to 3.8 against 1.5 for groundnut and 1.7 for sorghum (Chudawat, 1990). Mango and its products are fast emerging as an important foreign exchange earner also. Fresh mango varieties such as *Alphonso*, *Neelam*, *Totapuri* and *Chausa* are in great demand in West Asian countries and in Europe. Total export earnings from mango and its products during 1994-95 was about U.S. \$ 35 million (Singhal, 1996). This included fresh mango, mango pulp, pickles, chutney, slices in brine, mango juice, squash and mango powder. Favorable economics and a large export potential is reflected in an increase in area of plantations both under individual and under commercial farm sectors in southern India.

Mango fruit is a rich source of vitamin-A with 4800 units per 100 g. It also provides protein, minerals, carbohydrate, fat and small quantity of Vitamin-C and has calorific value of 50 (Shanmugavelu, 1987). An adult human normally requires 11,00,000 calories per year, which can be obtained from 0.44 ha of wheat cultivation or only 0.16 ha of mango cultivation. Similarly on the basis of yield, mango production (9000 kg/ha) is three times higher than that of paddy (3000 kg/ha). This is indicative of the fact that mango crop can play a vital role in meeting the nutritional and food requirements of the increasing population of India.

### 1.2 Pest and Disease Management in Mango Crop

Efficient nutrient and pest management is critical for varieties such as *Alphonso*, which constitutes approximately 95 per cent of total fresh mango export. Adequate use of nutrients, nitrogen, phosphorus, potash, calcium, magnesium, sulfur, zinc and boron can double the mango yield. Pest and diseases infestation affects quality, marketability and export adversely. Import of fresh mango from India was banned for some time in Japan and Srilanka due to the prevalence of fruit fly infestation (Singhal, 1996).

Mango is prone to several diseases and pest attacks resulting in severe economic losses causing about 20-40 percent yield loss (Shanmugavelu, 1987) which can be prevented by three phases of spraying at fresh twig and bud stage before flowering, at 60 percent flowering and at tender fruit stage. Mango orchard requires several sprayings of fungicides and insecticides in order to keep the crop disease and pest free.

Efficient spraying machine is crucial for effective control of diseases and pests. The main function of the spraying equipment is to generate droplets of uniform size and send them to the target tree enveloping it in the process. Presently available tractor mounted hydraulic sprayers apply high liquid volume of 3000–10000 liters/ha in very large drops (500 to 1000  $\mu\text{m}$ , vmd) for projection to the dense tree foliage. The energy required for atomization and propulsion of drops to tall trees are obtained from the spray liquid. It generally required 50-100 kW power units (Akesson and Yates, 1979). This type of sprayer is basically designed for row crop spraying, hence, the spray does not reach effectively to the tree top. Further, the large size droplets result in loss of chemicals as runoff. Therefore, use of row crop sprayers for mango crop does not make a right choice.

### **1.3 Conventional Methods of Spraying**

Currently, the mango orchards in India are sprayed with the help of manually operated rocker type hydraulic sprayers. This is illustrated in a photograph given in Plate 1.1. In this method, liquid discharged from the spray nozzles does not reach the remote locations in the tree canopy. The unexposed leaf surface remains unsprayed, leaving a survival ground for pathogens and pest species. Secondly, the slow pace of operation in a large orchard plot allows microorganisms and pests multiply faster on trees at the tail end area. Therefore, efficient spraying machines suitable for mango orchard needs to be developed.

### **1.4 Air Assisted Spraying in Orchards**

Air-assisted sprayers have been found most effective for spraying tree orchards (Matthews, 1992). In air-carrier spraying system, air stream developed by a blower is used as the medium to transport 100-300  $\mu\text{m}$  droplets generated by the atomizers to the tree foliage, which eliminates the need for larger droplets. This system provides uniform application of atomized spray particles over the tree canopy and requires minimum quantity of chemicals. Due to these reasons, air-carrier sprayers were imported by a leading manufacturer of spraying equipment in India, primarily to evaluate their feasibility for orchard crops. Preliminary assessment has shown that these machines are large and require more power than



**Plate 1.1. Conventional method of orchard spraying**

available on 35 hp (26.10 kW) tractors common in India (Turare, 1992). Hence, these units are not adopted for Indian conditions. Some efforts in modifying these units were made (Das, 1997), but no change in overall design and no major modifications have been reported so far.

Air-carrier sprayer consists of a blower, a liquid pump, valves, nozzles and other accessories. Blower is the prime component and it absorbs a great amount of power. Design of blowers has, therefore, been a subject of research. The air jet created by blower determines the performance of the sprayer.

### **1.5 Use of Axial-Flow Blower in Air-carrier Sprayers**

Centrifugal and axial-flow blowers are two common types of blowers used in air-carrier sprayers. Centrifugal blower is a good atomizer but poor transporter, while an axial-flow blower transport well with poor atomization (Klenin, et.al. 1985). Since blowers are used largely for transport of atomized fluid, axial-flow blowers are most widely used in air-carrier sprayers meant for orchards. As these blowers discharge large volume of air at low pressure, their performance depend on the shape and angle of blades in relation to the direction of rotation (Matthews, 1992).

An axial-flow blower blade of airfoil shape is similar to that of an airplane wing with a blunt leading edge and a thin trailing edge. The blade geometrical parameters, viz., chord, camber angle, incidence angle etc. besides number of blades and the size and speed of blower, are important factors that determine the characteristics of output air jet (Wallis, 1983). Spray distribution improves with increase in the volume of air applied. Hence, when energy available is limited, the ratio of air volume and velocity must be as large as possible (Randall, 1971). The velocity and turbulent kinetic energy along the centerline of air jet has shown to decay exponentially with penetration distance (Walklate, 1996). Blower design that produces an air jet, which matches with mango tree canopy size, needs investigation and development. Investigations on the effect of blower design parameters on creation of desirable air jet and subsequent transport of spray droplets to reach different parts of tree canopy would lead to the design of air-carrier sprayer suitable for mango orchards.

## 1.6 Design of Axial-flow Blower

Bleier (1998) states that several designs are possible that will meet a certain set of requirements with respect to air delivery and pressure. Hence, optimal design depends on many factors considering the specific problem under investigation. Wallis (1983) suggested a methodology for axial-flow blower based on empirical calculations using dimensionless variables. Eck (1973) proposed design procedures, which used elementary airfoil theory for design. Bailer and Corolus (1999) designed two axial-flow fans of different flow and pressure coefficients according to elementary airfoil theory of Eck (1973). Their theoretical design matched well with the results obtained from computational simulations. Thus, empirical methods are still used commonly for design of axial-flow fans.

## 1.7 Objectives

Despite large-scale mango plantations and its economic importance in India, non-availability of suitable spraying machines remains a major constraint in controlling production losses due to disease and pest. Conventional spraying equipments are slow. Prolonged operations and sparse coverage of tree canopy provides a survival ground for pathogens and pests. Therefore, this project aims to develop an air-carrier sprayer matching to requirement of local mango tree size and thereby improving productivity and profitability of mango production in India.

Although a review of literature suggests that models of air-carrier sprayer are available elsewhere, these designs are not directly adaptable to Indian conditions due to large blower size and high input power requirement. Blower is the most crucial component in an air-carrier sprayer. Hence, a systematic design of blower is strategically important in the successful development of air-carrier sprayer. Available blower sizes in India and elsewhere does not match the requirement of air-carrier sprayer for Indian mango orchards. Hence, it is necessary to develop an axial-flow blower applying established design principles. Empirical method given by Wallis (1961) is still considered to be a bible for axial-flow fan designers. Therefore, these empirical models and basic design principles still apply to obtain design parameters for axial-flow fan.

Canopy volume of mango trees decides the amount of air that should be used in air-assisted sprayer. Hence, morphological features of tree canopy size and volume would be the basis for calculating the air-flow requirements. As indicated by Bleier (1998) it is apparent that many designs would be possible in order to meet the same air-flow requirements. The

design of the blower would then be guided by many factors such as its size and adaptability to the power source. Moreover, empirical designs can only lead to those potential designs, which should further be tested using physical models before the designs are accepted. Blowers of suitable size and with features adaptable to sprayer requirement are not available easily. Hence, development of a good air-assisted sprayer demands design of a suitable blower.

Empirical designs lead to design of blowers, which perform fairly well. However, the main parameters of blower need be tested for optimum values. Physical testing involves varying these parameters in order to determine the optimum conditions.

A sprayer is successful if it can direct the spray droplets to the tree canopy properly and give a uniform spray application throughout the canopy. The air stream issued from blower would direct and distribute the spray-laden air into the canopy. Proper mixing of droplets in an air stream should be achieved by locating and orienting nozzles suitably. Thus, designing the air outlet location and orientation of the nozzle are key factors in developing the air-assisted sprayer. The overall sprayer should be tested in the field to confirm that the performance shown in the laboratory is reflected in actual field conditions. Thus, the field test establishes finally the suitability of new design of sprayer.

The general objective of the work was to develop an air-carrier sprayer for mango orchards in Andhra Pradesh. With the above points in mind, the specific objectives of present investigation were decided and given below.

### **General objective**

*To develop an air-carrier sprayer for mango orchards.*

### **Specific objectives**

1. Measurement of tree canopy volume and estimation of air flow rate requirement for air-assisted spray on mango tree.
2. Design of an axial-flow blower to meet air flow requirement for spraying in mango tree and optimization of its performance in laboratory conditions.
3. Development and performance evaluation of laboratory and field models of air-carrier sprayer.